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APPLYING THE BEHAVIORAL ECONOMICS PRINCIPLE OF UNIT PRICE TO DRO SCHEDULE THINNING

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Within the context of behavioral economics, the ratio of response requirements to reinforcer magnitude is called *unit price*. In this investigation, we yoked increases in reinforcer magnitude with increases in intervals of differential reinforcement of other behavior (DRO) to thin DRO intervals to a terminal value.

DESCRIPTORS: behavioral economics, differential reinforcement, reinforcement magnitude

Differential reinforcement of other behavior (DRO) involves the presentation of reinforcement contingent on the omission of a targeted response for a predetermined period of time. This procedure may offer some advantages in the treatment of problem behavior. For example, DRO may be applicable in settings where near-continuous access to reinforcement is inappropriate (Cowdery, Iwata, & Pace, 1990). Nevertheless, DRO also has some limitations, particularly when used in the treatment of behavior maintained by automatic reinforcement. Due to the lack of social control over automatic reinforcers, DRO as treatment for behavior maintained by automatic reinforcement may be conceptualized as a choice paradigm in which two different reinforcers (i.e., alternative stimulation and automatic reinforcement) are concurrently available. Thus, response allocation may depend on a variety of factors such as the quality of reinforcement associated with each response (Herrnstein, 1970).

It is not surprising that some research has shown DRO to be relatively ineffective in the treatment of automatically reinforced problem behavior. Shore, Iwata, DeLeon, Kahng, and Smith (1997) observed no decreases in automatically reinforced self-injurious behavior (SIB) during DRO even when participants' DRO intervals were relatively short (e.g., 5 s) and suggested that treatment failure was due to competition between reinforcement obtained from SIB and that obtained from the omission of SIB (i.e., access to preferred stimuli). That is, reinforcement obtained from SIB could be

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accessed immediately, whereas reinforcement obtained for the omission of SIB was delayed (via the DRO interval).

Unit price is a concept from the field of behavioral economics that may be useful when developing DRO schedules. In microeconomics, unit price refers to the expenditure given for a particular amount of a commodity and is expressed by the equation $P = R/A$, where P is the price of the reinforcer, R is the response requirement, and A is the magnitude of the reinforcer. In this equation, if the value of either R or A changes without concomitant changes in the other variable, the value of P will be altered. However, if R and A increase or decrease by the same constant (e.g., 20%), the value of P will remain constant. In an analysis of the effects of unit price on choice responding, Madden, Bickel, and Jacobs (2000) provided three predictions regarding the effects of unit price on responding. One prediction was that as the unit price of a reinforcer increases, responding for that reinforcer decreases. In the current study, we hypothesized that altering unit price during DRO schedule thinning would reduce the effectiveness of DRO as a treatment for automatically reinforced problem behavior. We also hypothesized that the effectiveness of DRO would be sustained during schedule thinning if the unit price of the reinforcer was held constant during the thinning process.

METHOD

Participant and setting. Fred was a 16-year-old boy who had been diagnosed with autism and mild mental retardation and had been referred to a day-treatment program for the assessment and treatment of multiple topographies of destructive behavior (i.e., self-injury, aggression, inappropriate sounds). All sessions were conducted in a room (3 m by 3 m) equipped with a one-way observation window, a table, chairs, and other stimuli (e.g., toys) that varied depending on the condition in effect. With the exception of the extended-duration alone sessions, all sessions were 10 min in duration, and five to eight sessions were conducted daily.

Response measurement and reliability. Inappropriate sounds were defined as singing, humming, imitating musical instruments, or making repeated requests (e.g., saying "outside"). This response was targeted for reduction based on caregiver complaints of its volume and intrusiveness in classroom and home settings. Duration data were collected on the occurrence of inappropriate sounds during all analyses regardless of whether they occurred during reinforcement and DRO intervals. Observers used laptop computers to record the number of seconds in which the behavior occurred. The resulting duration was then divided by the total session duration (e.g., 600 s) to yield the percentage of time in which the response occurred.

Interobserver agreement was measured during 57% of all sessions by partitioning each session into 10-s bins and dividing the smaller duration recording by the larger duration recording within each 10-s bin, summing these measures across all 10-s bins, and multiplying the resulting quotient by 100%. Average agreement for inappropriate sounds was 91% during the functional analysis, 93% during DRO thinning with increasing unit price, and 99% during DRO thinning with constant unit price.

Functional analysis. A functional analysis (based on Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) was conducted to identify the variables that maintained Fred's inappropriate sounds. Four test conditions (attention, demand, alone, tangible) and a control condition (toy play) were compared in an alternating treatments design. Following the functional analysis, a phase of extended-duration (20-min) alone sessions was conducted (Vollmer, Marcus, Ringdahl, & Roane, 1995).

DRO thinning: Increasing unit price. Following completion of the functional analysis, a DRO schedule was implemented to decrease the occurrence of inappropriate sounds through

the presentation of an alternative stimulus (i.e., a radio; identified as highly preferred based on a stimulus preference assessment described by Fisher et al., 1992). The baseline condition was identical to the alone condition of the functional analysis except that a therapist was present in the room with Fred (to control for therapist presence during the DRO condition, when it was necessary for reinforcer delivery) and the radio was not present. During the DRO, Fred received access to the radio for 20 s contingent on the completion of a 10-s DRO interval. Specifically, the therapist turned on the radio and handed it to Fred for the duration of the reinforcement interval. If Fred engaged in inappropriate sounds during the DRO interval, a timer was reset to zero, and a new 10-s interval was initiated. There was no programmed contingency in place for the occurrence of inappropriate sounds when Fred had access to the radio. The DRO schedule was thinned by increasing the 10-s interval by 50% following two or three consecutive sessions in which the level of inappropriate sounds was at least 90% lower than that of the previous baseline mean. The DRO interval increased from 10 s, to 15 s, to 23 s, and so on until the terminal interval of 180 s was attained or inappropriate sounds increased to unacceptable levels. Across all increases in the DRO interval, the reinforcement interval remained constant at 20 s. Thus, *R* increased by 50%, whereas *A* remained constant at 20 s; therefore, the price (*P*) of the reinforcer increased each time the schedule was thinned. The baseline and DRO conditions were compared in a reversal (ABAB) design.

DRO thinning: Constant unit price. This analysis was conducted in a manner similar to that of the DRO analysis described above; however, the magnitude of the reinforcer (*A*) increased in conjunction with increases in the DRO interval (*R*). Thus, the relative price of the reinforcer (*P*) was held constant as the DRO interval increased. For example, the first change involved the DRO interval increasing from 10 s to 15 s while the reinforcement interval increased from 20 s to 30 s, so that the reinforcement interval remained twice the duration of the DRO interval, until the terminal DRO interval of 180 s was achieved. That is, increases in *R* and *A* were proportional such that *P* remained constant each time the schedule was thinned. The baseline and DRO conditions were evaluated in a reversal design (ABAB). In addition, the initial and terminal DRO schedules were compared using a multielement design in the second phase.

RESULTS AND DISCUSSION

Results of the functional analysis revealed undifferentiated patterns of responding (Figure 1). In addition, inappropriate sounds persisted during the extended-duration alone sessions ($M = 94\%$), suggesting that this behavior was maintained by automatic reinforcement.

Figure 1 also shows the results of the initial DRO analysis in which access to the reinforcer remained constant (20 s) across the increasing DRO schedules (i.e., the unit price increased). High levels of inappropriate sounds occurred during baseline ($M = 98\%$), and responding decreased when the 10-s DRO was implemented ($M = 0.2\%$). Following a return to baseline ($M = 99\%$), low levels of inappropriate sounds were again observed; however, higher levels of inappropriate sounds occurred when the DRO interval reached 23 s (for 20 s of reinforcement; $M = 55\%$ for the 23-s DRO).

The results of the DRO with constant unit price are shown in Figure 1. Following baseline ($M = 97\%$), two DRO conditions were compared in a multielement design. Levels of inappropriate sounds were higher and resembled those of baseline during the 180-s/360-s condition ($M = 94\%$) relative to those observed in the 10-s/20-s condition ($M = 14\%$), suggesting that the terminal DRO schedule (DRO = 180 s; reinforcement interval = 360 s) did not maintain low levels of in-

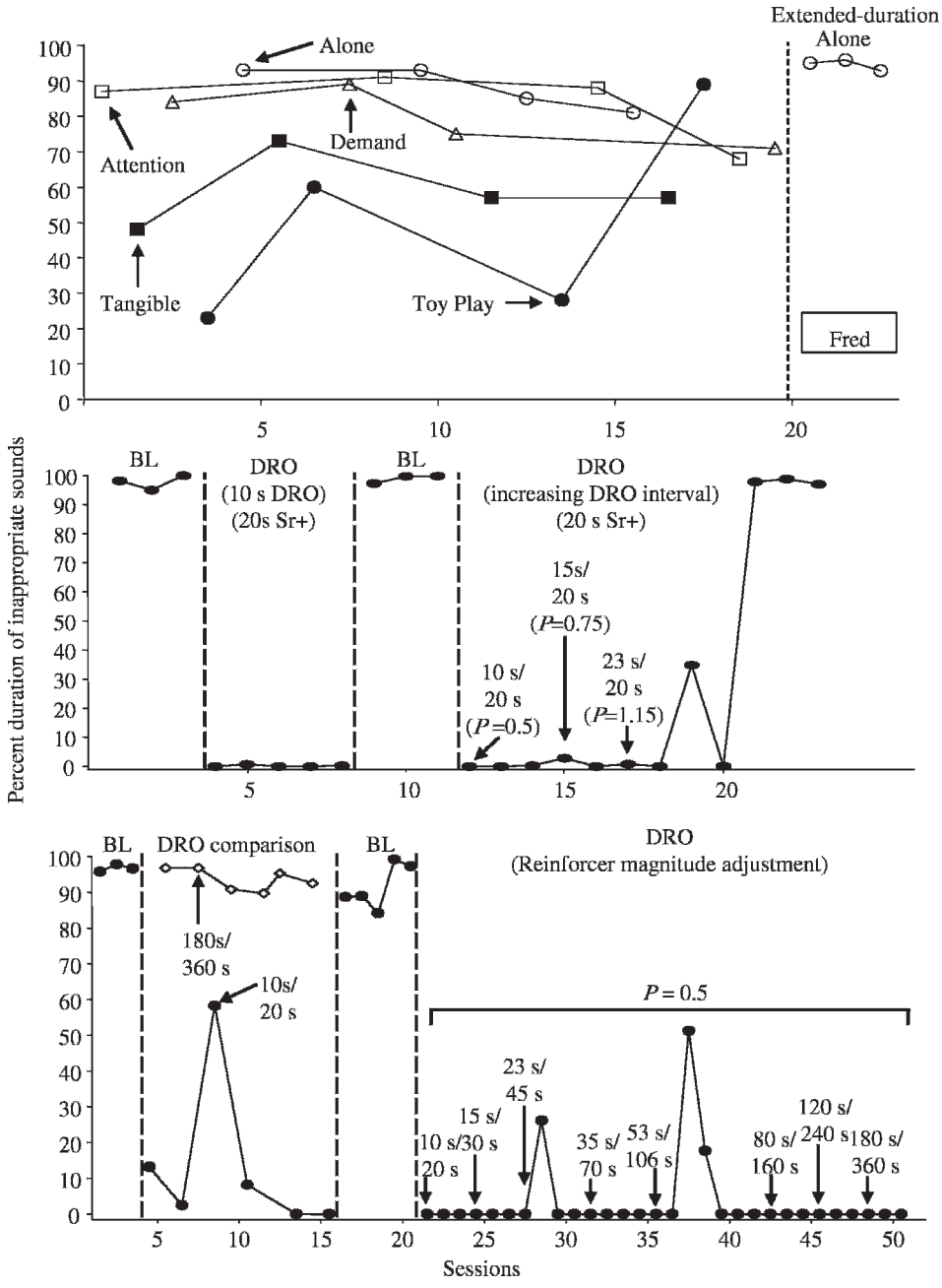

Figure 1. Percentage duration of inappropriate sounds during the functional analysis (top), DRO thinning without unit-price adjustments (middle), and DRO thinning with unit-price adjustments (bottom). BL = baseline. The top numbers above the arrows indicate the DRO interval lengths, and the bottom numbers indicate the reinforcement interval lengths.

appropriate sounds prior to thinning. Following baseline (M = 92%), the DRO schedule was thinned while the unit price was held constant (i.e., reinforcer magnitude was yoked to increases in the DRO interval). With the exception of the 23-s/45-s and 53-s/106-s ratios, near-zero levels of inappropriate sounds were observed throughout the DRO thinning analysis in which the reinforcement interval was always twice that of the DRO interval.

During the first DRO thinning analysis, the price of the reinforcer increased as the DRO schedule was thinned because the DRO interval increased and the reinforcement interval remained constant (20 s). Initially, the ratio of the DRO interval to the reinforcement interval was 1:2 and the price of the reinforcer was 0.5. Thereafter, the ratio increased to 1.5:2 and then to 2.3:2, with corresponding increases in the price of the reinforcer to 0.75 and 1.15. Thus, the DRO became ineffective when the DRO interval reached 23 s (for 20 s of reinforcement). From an economic perspective, it is likely that the price of the reinforcer became too high relative to the response requirement, which resulted in more responding toward inappropriate sounds. This outcome is similar to the predictions described by Madden et al. (2000). In addition, this result was similar to other interpretations of DRO failures being related to relative competition between the reinforcer that maintains problem behavior and alternative sources of reinforcement (Shore et al., 1997). By contrast, when the unit price was adjusted to maintain a 1:2 ratio of the DRO interval to the reinforcement interval, the DRO interval was thinned to 180 s (for 360 s of reinforcement). That is, by keeping the price of the reinforcer constant at 0.5 (i.e., yoking the magnitude of the reinforcer to increases in the DRO interval), the DRO schedule was thinned to its terminal value and low levels of inappropriate sounds were maintained. It should be noted that neither schedule thinning alone (as demonstrated in the initial DRO analysis) nor adjusting the unit price only (as seen in the initial 180-s/360-s condition of the DRO thinning with constant unit price) was effective at reducing inappropriate sounds. It was only when schedule thinning was used in conjunction with yoked increases in reinforcer magnitude that the DRO schedule was successfully thinned. Thus, gradually increasing the DRO interval and maintaining a constant unit price were both necessary to reach the terminal DRO schedule while maintaining low levels of problem behavior.

In the current investigation, the 1:2 ratio between the DRO and reinforcement intervals was determined arbitrarily. It is possible that a less disparate ratio would have produced low levels of problem behavior. Also, the two schedule-thinning procedures (one with an increasing unit price and one with a constant unit price) were each implemented once. Thus, without a replication of each DRO procedure, it is not possible to definitively conclude that changes in the unit price of the reinforcer altered the effectiveness of the DRO contingency. Nevertheless, the results are consistent with behavioral economic principles and with the specific predictions made by Madden et al. (2000). However, additional research is needed to further evaluate and replicate these findings regarding the effects of unit price during reinforcement thinning.

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